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Division 11
NATIONAL DEFENSE RESEARCH COMMITTEE
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DEVELOPMENT OF TEST UNIT FOR PRODUCTION OF OXYGEN BY A REGENERATIVE CHEMICAL

to
March 30, 1945
by
C. J. Matthew

Report OSRD No. 5150
Copy No. 33
Date: May 31, 1945

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NATIONAL DEFENSE RESEARCH COMMITTEE
of the
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DEVELOPMENT OF TEST UNIT FOR PRODUCTION OF OXYGEN BY A REGENERATIVE CHEMICAL

Service Directive NL-B42; NS-117

Endorsement (1) from H. M. Chadwell, Chief Division 11 to Dr. Irvin Stewart, Executive Secretary of the National Defense Research Committee. Forwarding report and noting:

> "This is a detailed report of the installation and operation of an oxygen generating unit developed by NDRC, upon a Naval vessel in a forward operational area."

This is a progress report under Contract 11-201, OEMsr-269 with A. D. Little, Inc.

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ARTHUR D. LITTLE, INC.

Cambridge, Massachusetts

OEMsr-269 March 30, 1945

We wish to herewith transmit the report of Mr. C. J. Matthew of our staff concerning his inspection, operation, and testing of the regenerative oxygen unit installed by this contractor on the U. S. S. Prairie in October of 1943.

This report includes a detailed review of the operation during the trial run after installation, a history of the unit's performance during the period from these initial tests until Mr. Matthew's inspection late in December of 1944, and a detailed review of his inspection lasting from December 26,1944 to February 9, 1945.

Mr. Matthew visited the U. S. S. Prairie in the capacity of a U. S. Naval Technician sponsored by the Bureau of Ships. His orders, a copy of which follows this letter, were "to furnish technical advice to your Commanding Officer regarding experimental plant for the production of welding oxygen and such other products as may be deemed expedient or necessary."

Mr. Matthew reported verbally on his trip, to the Bureau of Ships at a conference on March 13, 1945. This report serves to place in writing the material presented at that conference.

It is our understanding that this completes our assignment in this connection.

Respectfully submitted,

T. L. Wheeler

CONFIDENTIAL

T. L. Wheeler
Supervisor

Benjamin B. Fogler

Benjamin B. Fogler
Chemical Engineer

CONFIDENTIAL

C Section 257a
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Y

NAVY DEPARTMENT
BUREAU OF SHIPS
WASHINGTON, D.C.

2 December 1944

To: Technician Christian J. Matthew.

Subj: Orders to Duty with U. S. Navy.

Ref: (A) CNO Serial ltr. of credentials SHIPS-1763.
(B) Regulations Governing Technicians (OPNAV 30-SA).

Encl: (U.W.)
(A) BuShips ltr. LS(257a) of 25 February 1944.

1. You have been directed by your employer, Arthur D. Little, Inc., Cambridge, Mass., to report to the Chief of the Bureau of Ships for duty with the U. S. Navy. Reference (a) accredits you as a technician sponsored by this Bureau. Reference (b) defines your status and describes your privileges and responsibilities. You have been provided a copy of these regulations and will be governed by them.

2. You will report on or about 7 December 1944 to the Commandant Twelfth Naval District for first available air transportation to Pearl Harbor, T.H. Upon arrival at Pearl Harbor, you will report to the Commander, Service Force, Pacific Fleet, for such duty as may be assigned by him, or by any Commanding Officer to whom he may order you to report.

3. You are required to furnish technical advice to your Commanding Officer regarding experimental plant for the production of welding oxygen and such other products as may be deemed expedient or necessary.

4. You are directed to travel by government and/or commercial air wherever necessary to expedite completion of these duties.

5. On the first of each month you will forward to this Bureau (Code 257a) a product and activity report for the preceding period. Such reports will be transmitted as outlined in enclosure (A).

6. Upon completion of this duty and when directed by the Commander, Service Force, Pacific Fleet, you will return to the United States for further assignment, reporting to your employer and by letter to this Bureau, returning your letter of credentials to this Bureau.

E. L. COCHRANE

cc: ComServPac
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ARTHUR D. LITTLE, INC. COPY NO. 30

Cambridge, Massachusetts OEMsr-269

FINAL REPORT ON DEVELOPMENT OF TEST UNIT FOR PRODUCTION OF OXYGEN BY A REGENERATIVE CHEMICAL

To: Office of Division 11
National Defense Research Committee

The following is a detailed report of my activities and observations concerning the regenerative oxygen unit while aboard the U. S. S. Prairie, as well as a history of the unit since its installation aboard ship.

History of Unit

September 1943 to December 1945

In September, 1943 the regenerative oxygen unit was installed aboard the U. S. S. Prairie at South Boston, Massachusetts. Shortly after the completion of the unit, the ship embarked on a ten-day cruise off the coast of New England. During this time, the unit was operated intermittently in order to familiarize the crew with it, as well as to observe its operation at sea. The unit operated very smoothly and was well received by the officers and men on the ship.

At the end of this trial period, the Clark Brothers' dry oxygen compressor was disassembled in order to inspect the cylinders and piston rings. The machine was found to be in excellent condition with the exception of the carbon piston rings. There was no indication that they were beginning to wear, but, in almost every case, the overlapping joints on the three segments of each ring had snapped. The pieces had remained in place so that the efficiency of the compressor had not been noticeably impaired.

Nevertheless, new rings were installed, and the compressor reassembled to continue operation. Although this test run aboard ship was rather short, everything indicated that the unit should operate as successfully on shipboard as it had during the experimental stage in the laboratory.

October 1943 to June 1944

In October, 1943 the U. S. S. Prairie was ordered to duty in the Central Pacific. This was most unfortunate since the unit had been designed to operate in a cool climate. The Prairie had originally been selected expressly as the ship on which to install the plant because it was then in Newfoundland where atmospheric conditions and the temperature of the sea water are ideal. This change in operating locale meant that the unit was due for a most strenuous trial period. Both the officers on the ship and the interested personnel at the Bureau of Ships were informed of the unit's limitations, but at the same time these men were eager to see how it would stand up under the unfavorable tropical conditions.

For the next month or two, the ship was under way most of the time so that the unit was run very little. Shortly after they reached Pearl Harbor, however, serious difficulties were encountered. Both the air temperature and the harbor water were in the neighborhood of 80°F. This elevated temperature cut down the hourly production of oxygen as had been expected. The warm sea water, however, produced a much more serious difficulty. During a period of operation shortly after reaching Pearl Harbor, the operators of the unit were startled to see a large stream of water suddenly flow from the exhaust air line. Indications were that a failure had occurred in the copper tube element in the reactor. Upon inspection, a number of holes were found in the immediate vicinity of the silver-soldered joints of the copper return bends. This pitting was undoubtedly caused by the electrolytic action of the sea water at this bi-metallic joint. It was therefore felt unwise to try to repair the tubes, because of an almost certain reoccurrence of this action. However, the officers and men associated with the unit, were convinced that the unit would operate successfully if the reactors were built with cupro-nickel tubing, and that such a change was worthwhile.

In spite of the pressing conditions which exist in the forward area during wartime, the men set out to overhaul the entire unit and build new reactors. The salt water had caused considerable corrosion in the lines, so that they had to be cleaned with wire brushes. The Lunkenheimer quick-acting valves were all taken apart and cleaned. The Clark Brothers' compressor was also disassembled for a complete inspection and overhaul. The cylinder walls had been pitted by the water and had to be honed out. Simultaneously with this revamping, a new reactor was designed and built. In general, it was similar to the original case except that the copper fins were of heavier material and fewer in number. To overcome the electrolytic action of the sea water, cupro-nickel tubes were used, and finger zincs were placed in the inlet water line. When the unit was put into operation with the single case, everything performed well, but there was no oxygen produced. This was very disappointing to all, to say the least, especially in light of all the time and effort spent in rebuilding it.

Up to this time, the unit was operated by several men in the boiler shop, where it was located. The outside boiler repair work that these men were called on to do had increased to such a degree that they were no longer able to devote much time to the oxygen plant. It was therefore decided to relieve them of this extra duty in favor of someone who might have more time and also be capable of getting the unit into operating condition.

June 1944 to Dec. 1944

In June, 1944, the unit was turned over to the chief machinist's mate in charge of the refrigeration shop. It was apparent to the officers in charge that some knowledge or appreciation of heat transfer was necessary to design a new reactor for the unit. Their selection of the man named above was based on this reasoning, since he was undoubtedly better qualified than any other person on the ship.

At the outset, he studied the manual of operation and maintenance of the unit, and reviewed its operation since its installation aboard ship. He examined the reactor built on the ship and felt that its failure to operate successfully was due to poor transfer of heat. While the number of fins was less than in the original case, many of them had not been soldered to the tubes, and therefore were not contributing to the transfer area. He felt that with the experience gained by the other men, and with his knowledge of the heat transfer aspects of the problem, he could design a new reactor that would operate successfully.

This new case was to have several new features or improvements. In order to eliminate the problem of silver-soldered return bends, the cupro-nickel tubing was cold bent before the addition of the fins. The open end of the tubes was then rolled into a brass tube sheet. A header was also cast which could be bolted to the tube sheet, and to which was attached two removable zinc plates. With the exception of the header, the general shape of the reactor was the same as that of the original units, so that it would fit into the cylindrical steel shell or outer casing. The reactor had 36 cupro-nickel U-tubes with 177 copper fins on each arm of the tubes. Each fin was stamped out and soldered to the tubes by hand. From this operation alone, it is perfectly evident that the men on the ship wanted to give the unit every possible chance to prove itself.

One difficulty was encountered, however, in the construction of this new reactor. The glass wool supply on the ship had been depleted, so that none was available to insert in the bottom filter of the case. The glass wool in the original units had become coated with rust and sediment, due to the salt water entering the cases, and could not be reclaimed. Because of the length of time required to obtain a new shipment of glass wool, it was decided to substitute felt pads in the filter.

At this time another very excellent addition was made to the unit. As stated earlier, this unit was originally designed to operate in a cool climate. Now that the ship was in the tropics, thought was given to the possibility of installing refrigerating units for the water and air. Because of the large quantity of sea water flowing through the unit, calculations showed that the size of the refrigerator and circulating tank required to cool the water would be prohibitive. However, it was felt that a small cooling unit installed in the air line would be very advantageous. It would serve not only to cool the air, which is desirable for good absorption, but also to condense out a considerable quantity of water which is present in the humid tropical air. The latter, of course, has a considerable effect on the humidity of the oxygen produced. A small, brine, refrigerator unit was therefore installed capable of cooling the air required, to about 60-65°F. It was also able to maintain this temperature for an operating period of four or five hours.

In August, 1944, the new reactor was finally completed and the refrigeration unit installed. Several necessary changes were made in the piping in order that the unit might be operated with the single reactor. All the valves had been cleaned so that the plant was in readiness for a new start. Immediately upon being put into operation, oxygen was produced, much to the joy of all concerned. It continued to operate successfully for several hours, indicating, at least, that the heat transfer problem had been overcome. After a day or two of trial running, several of the quick-acting valves either failed to open or close at the proper time, thereby seriously disturbing the operation of the unit. It was noted that in no case had the water or steam valves failed to operate correctly, but rather, only those in the lines carrying the gases. In several cases, the plunger rod of the valve had become lodged so tightly in the packing that it was impossible to move it with the 50 p.s.i. gage compressed air actuating the bellows. Upon investigation, this binding was found to be caused by fine Salcomine powder getting between the packing and the plunger rod. In other cases where valves had failed to close properly, the Salcomine had also caused the trouble. The fine powder became lodged on the composition seat of the valve, and gradually built up until there resulted a hard cake of the chemical which prevented the valve from closing tightly.

After eliminating all other possible sources of this disturbance, it was finally decided that this fine powder was in some way by-passing the bottom filter. This meant that either the felt was not a satisfactory filtering material, or that the filter had not been built sufficiently tight to prevent such leakage. In order to inspect the bottom filter, it would have been necessary to tear open the outer casing of the reactor which would have taken considerable time. This was not deemed wise, since the unit was producing oxygen, and could be run satisfactorily if the valves were cleaned periodically. As a result, two men were assigned to stay with the unit and keep the valves in operating condition.

The regenerative oxygen unit was again supplying oxygen to the various repair shops for welding, brazing, soldering and cutting. Because it was operating with only one reactor, it was necessary to ration the oxygen, to some extent. In general, men doing extensive cutting of steel plate were asked to use cylinder oxygen, so as not to drain too much on the storage system of the unit. The following is a list of operating conditions and oxygen production of this single reactor with a fresh charge of Salcomine:

Air Temperature	60-65°F.
Air Pressure	90 psi gage
Water Temperature	85°F.
Water Pressure	20 psi gage
Oxygen Produced (approx.)	60 cu. ft. per hr. at S.T.P.
Purity of Oxygen (approx.)	97%

As can be seen, the hourly production of this single case is slightly less than one half that obtained on the east coast. This is not too far from prediction, however, considering the difference in cooling water temperatures. This production continued at about the same level for 400 or 450 cycles. At this point, however, there was a sharp drop in production so that the chemical had to be removed and a new charge put in. This phenomenon is quite strange, for it had never occurred in any of the laboratory experimental work. There always had been a gradual dropping off in production, but never a sharp drop of this nature. At the point of this sharp decline, the Salcomine had only produced between 4 and 4.5 times its weight in oxygen. This is far short of what had been predicted from the experimental work. Two or three new charges were tried in the unit, but with the same result. One charge remained active for 500 cycles, but then became exhausted, as had the others. Since the unit was operated about 4 or . 5 hours a day, this meant that the Salcomine would have to be recharged about once a month. Also, operating in this fashion, it was estimated that the single reactor was supplying about 40% of the ship's needs. It was therefore felt that if three reactors were built, they would be able to produce all the oxygen the ship needed, and the unit would not have to operate as long each day. This in turn would lengthen the period between the loading of the reactors.

Plans were immediately laid to build two more cases similar to the one in operation. At this same time, word reached the ship that three new reactors were being sent out from the Bush Manufacturing Company of Hartford, Connecticut. The ship was also notified that I would also be coming out to inspect the unit so it was decided to cancel the plans for building the two more cases.

Dec. 1944 - Feb. 1945

On December 26, 1944, I reached the U. S. S. Prairie, then stationed at Ulithi. My first activity was to investigate the past history of the oxygen plant, as related above. While learning about the difficulties encountered during the preceding fifteen months, I was also able to see a batch of Salcomine become exhausted in the strange manner described earlier.

The new reactors were not due to arrive for two more weeks, so it was decided to take advantage of this time for a complete overhaul of the unit. All the valves and lines were cleaned of the fine Salcomine powder that had been causing difficulties. The air and steam filters and traps were inspected and cleaned where necessary. The oxygen compressor, too, was disassembled for inspection. Once again, the piston rings were found in pieces, although the operation of the compressor had not been noticeably affected. There was no particular evidence of wear in the rings, although they had been installed about a year previously. The piston rods had worn slightly along the length that passed through the oil-scraping rings, so were replaced. The carbon packing rings were somewhat pitted, so they too were replaced. To complete the overhaul of the compressor, an entirely new set of valves was lapped in. The oxygen unit was then in readiness for the installation of the new reactors by the middle of January.

When the new reactors arrived, it was found that several changes would have to be made in order to install them in the cylindrical shells. The steel frame with studs on the top of the reactor, to which the copper cover was bolted, was found to be just a bit too heavy, thus preventing the reactor from sliding into the outer casing. The frame was chipped off and replaced by one of lighter stock. Instead of studs, holes were drilled and tapped in the frame so that small bolts might be used to secure the copper cover on the finned tube element. All the inlet and outlet tubes of the reactor were brazed to the flanges, instead of being flared out as in the original cases. With the exception of these changes and the substitution of copper-nickel tubes for copper, these reactors were the same as those in the original unit.

Approximately 125 pounds of Salcomine was then charged into each case and the three cases were installed in their proper places. Since it was not feasible to install zincs in the old-type headers, finger zincs about six inches long were placed in the sea-water line entering each case. The installation was now complete, so a trial run was started. Within a very few minutes, several of the valves failed to operate properly. Upon inspection, fine Salcomine was found to have accumulated, as noted previously. After a thorough cleaning of the valves, the unit again was started up. In a short time, the same difficulty was encountered. Just as before, this fine dust was by-passing the filters. For the rest of the day, attempts were made to keep the unit running, but the breakdown occurred about every fifteen minutes. It was obvious that we could not hope to run the unit with this constant problem.

In order to remedy the trouble at its source, the bottom filters of the reactors, the new cases would have had to be torn apart. This would have taken quite a lot of time and labor, neither of which was available. To make the situation even more serious, the supply of oxygen on the ship had become quite low, and it was hoped that the unit might be put into operation very shortly. Therefore in order that we might operate the unit without rebuilding the filters, additional filters were placed in the exhaust air line immediately after the cases. These filters consisted of a 12-inch length of 4-inch pipe, filled with glass wool, with perforated plates and screens at either end of the pipe to prevent the glass wool from entering the system. With the addition of these filters, it was again possible to operate the unit without having the valves stick. All the fine powder that by-passed the filters in the reactors was retained in these pipe filters, thus assuring clean air for the operation of the unit.

By means of the pressure drop between the inlet and outlet air, it was possible to determine whether these new filters were being plugged by the powder. Number 3 reactor appeared to be by-passing considerably more powder than the others, causing severe channeling of the air. This was indicated by the poor oxygen yield, as well as by the excessive powder escaping. It was deemed wise, therefore, to cut it out of the system until the time when the bottom filter could be repaired. The unit was then put into continuous daily operation with the two reactors. The operating conditions were the same as reported above for the single case, and the production for each case was also about the same. From this standpoint, it appeared that the single reactor built on the ship was just as capable as the new units made by the Bush Manufacturing Company. Incidentally, the former unit was being held as a reserve in case any serious failure should develop in any of the other cases.

Throughout this report, very little mention has been made of the purity of the oxygen. When the unit was installed on the ship, a Pauling oxygen meter was left with the men in order that they might obtain purity readings. At the time the ship left the East coast, the oxygen was at least 99.5% pure, according to the meter. From that time on, very little is known about the purity since the instrument failed to operate properly, this probably being due to mishandling. What was more important in the minds of the men on the ship was the quality of the flame produced in the oxyacetylene torches. For the most part it appeared to be perfectly satisfactory. Occasionally complaints were heard from men using it in cutting torches, who claimed that too much slag was formed. This condition could well be due to impurities in the oxygen, and also to the condition of the tip of the torch, as well as the experience of the man using it.

A 100-cc, glass sampling tube was also originally included with the unit as a means of testing the gas produced. This piece of apparatus was similar to an ordinary 100-cc. sampling tube with stopcocks at either end. At one end, however, the tube was drawn out in the shape of a graduate. This section was carefully graduated in order to determine the percentage of impurities, and its volume was about 10 cc. To make a determination, the gas was passed through the tube until it was completely purged of all the air. The stopcocks were then closed and the tube was filled until it contained 100 cc. of the gas to be analyzed. A standard pyrogallol solution was then allowed to enter the tube to absorb the oxygen. The tube was shaken continuously for several minutes until all of the oxygen had been consumed. Then by immersing it in a pail of water and opening the bottom stopcock, water rushes in to overcome the vacuum produced in the tube. The amount of gas remaining is impurity and can be read directly. While this method of analysis is perfectly sound, it requires considerable technique and patience to obtain consistent readings with high-purity oxygen. To make matters worse, the bottom stopcock has an imperfection so that some air leaks in when a vacuum is created in the tube. As a result, determinations made with this apparatus are only approximate and are on the low side.

When the unit was finally in operation again, another crude experiment was carried out to determine how the humidity of the oxygen which was produced compared with cylinder oxygen. The following is a set of data obtained:

Cylinder Oxygen		N.D.R.C. Unit Oxygen	
Wet bulb	76°F.	Wet bulb	68°F.
Dry bulb	93°F.	Dry bulb	95°F.

From these data, the gas produced on shipboard was considerably drier than was that particular cylinder oxygen. In some ways this is rather surprising. At any rate, the quality of the gas is sufficiently high to satisfy all the men using it, with the few exceptions mentioned above. The complaints have not been too well-founded and have not been taken seriously by the ship's officers.

Impressions of the Officers and Men

Undoubtedly the best appraisers of this oxygen unit are the officers and men who have been directly associated with it during the past eighteen months. In spite of the large number of difficulties encountered throughout this trial period, the general impression is very favorable. The Captain and Oxecutive Officer both pointed out that the troubles were all mechanical in nature and could be readily overcome by simple changes in design or materials of construction. They felt that the unit very definitely had a place on that type of ship and would be an excellent addition to all tenders and repair ships. The ability to make oxygen when it is needed, rather than wait for a shipment of cylinders, is, without question, a decided advantage. In addition, having the gas piped to the various shops, rather than carrying the cylinders around, is convenient as well as being time- and labor-saving. All these factors are especially important to a ship operating in the forward area.

Among the crew, however, the impressions were not always as favorable. This was especially true among the men who have labored tirelessly with it. This is readily understandable, considering the intense heat and the pressing conditions under which they have had to work. The main complaint was that the unit was not dependable, thus necessitating undue attention and labor. In general, however, they, too, seem to feel that it can be made into a dependable working unit with a few changes in design.

Recommendations.

In light of the difficulties encountered in the operation of the regenerative oxygen unit, and the experience gained during the past eighteen months, a number of suggestions or recommendations might be made. Most of the changes that might be recommended concern the reactors. To begin with, it would be very convenient if the outer cylindrical shells of the reactors could be eliminated. This would make the operation of loading and unloading the cases much simpler. The reactors could be somewhat similar in shape to the present finned-tube element, with materials of construction sufficiently heavy to withstand the air pressure.

It would also be very desirable to eliminate the silver-soldered return bends in the case. This could be accomplished in one of two ways. A case might be built similar to the one built by the ship's crew, in which the cupro-nickel tubes were cold bent before the addition of the fins, and then rolled into a brass tube sheet at the inlet end. A cast header containing removable zincs could also be bolted to the tube sheet, as described earlier. A second proposed design would eliminate the bends entirely by having tube sheets and headers at either end. This would eliminate the fear and possibility of denting the return bends in the operation of loading the cases. Another advantage that the latter design presents is the ease of being able to repair any tube, should failure occur.

A further change recommended in the design of the reactor involves the bottom filter. As has been pointed out throughout this report, a great deal of trouble has been caused by the fine Salcomine powder by-passing the bottom filter. Because of the present design, it is impossible to repair the filter without tearing the case apart. This difficulty could be overcome, however, if the bottom filter were removable, similar to the one at the top of the reactor. The change would also simplify the construction of the cases. In addition, the problem of unloading the chemical from the cases would be simplified by this design. At present, the cases are unloaded by tapping them with boards and by vibrating them with a pneumatic hammer. Since it is impossible to see to the bottom of the case, this vibrating action must be continued until the weight of chemical removed approximates that charged into the reactor. This is unsatisfactory, since the weights are not very accurate. It is therefore possible to have a certain amount of the exhausted Salcomine still in the case when a new charge is put in. It is also very probable that the old powder remains stuck to the fins, cutting down the efficiency of heat transfer to the new charge. If the bottom were removable, however, this problem would be overcome. It would be possible to use compressed air to blow out the last traces of the chemical which, with the open bottom, would be visible.

As was mentioned previously, the present shipboard unit is operating with supplementary, glass-wool filters in the exhaust air line. Since it is so important that all traces of Salcomine be removed from the air so as not to interfere with the operation of the valves, it might be wise to include filters such as these in any future units, just as an added safety precaution.

The problem of the plunger rods of the quick-acting valves sticking in the packing was the basis for another suggestion made by the man in charge of the unit on the ship. He felt that the trouble could be overcome if the packing of the valves were replaced by small bellows. No sediment would then interfere with the action of the plunger rod. This change would not be necessary, of course, if the filters were properly constructed, but in any event could not prove detrimental.

The factor which is undoubtedly causing most concern in this chemical oxygen unit is the strange deterioration of the Salcomine. As was reported, the sharp decline in production after 500 cycles was never experienced in the experimental work. However, none of this work was carried out using cooling water as warm as that experienced on shipboard. The unit was intended for operation in cool climate, and its design and time cycle of operation were based on this assumption. Therefore, before any statements can be made concerning the chemical, further studies should be carried out with it under extreme conditions. With the time cycle employed on the U. S. S. Prairie unit, the chemical never becomes saturated with oxygen and always is completely desorbed before the end of the desorption period. This constant strain, together with the warm water, may be the cause of the strange action. In any case, it is certain that a more suitable time cycle can be attained for these tropical conditions. It is possible that a timer might be developed whereby the cycle can be regulated according to the atmospheric conditions under which the ship is operating.

Another unknown that is being investigated is the effect of storage at sea on the absorption properties and life of Salcomine. Samples of the chemical for this study are being sent from the ship to Dr. T. A. Geissman of the National Defense Research Committee laboratory at the University of Pennsylvania.

Some thought should also be given to a means for testing the oxygen produced. For the present, it would probably be advisable to send a Hayes Orsat apparatus to the ship to replace the equipment which no longer gives true analyses.

If serious study were given to some of the above suggestions, I am sure that the present regenerative oxygen unit could become a dependable automatic plant.

Conclusion

In conclusion, I should like to express my sincere gratitude to the officers and men with whom I had contact on the U. S. S. Prairie for their excellent cooperation, and their untiring efforts to give the shipboard oxygen plant a fair trial.

Respectfully submitted,

Christian J. Matthew

Christian J. Matthew
Chemical Engineer

T. L. Wheeler

T. L. Wheeler
Supervisor

March 30, 1945

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Jan 28 - Feb 1, '46

Declassified per OSRD List on 6 Aug 49

6

(23) * Test equipment

Oxygen

P.09/01